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SOME CAUSES OF NATURAL TREE MORTALITY IN OLD-GROWTH PONDEROSA PINE STANDS IN WESTERN MONTANA

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ABSTRACT

Natural phenomena capable of quick-killing (within 1 year) mature ponderosa pine trees in western Montana were studied from 1948 to 1965. Of the 406 trees that had died of the 10,600 pine trees observed during this period, 57 percent had died from the effects of windstorms, 27 percent from attacks by bark beetles of the genus Dendroctonus, 7 percent from other but unknown causes, 6 percent from attacks by phloem-feeding insects other than Dendroctonus, and 3 percent from lightning strikes. The mean annual mortality of pine covered by these causal categories amounted to 78 board feet per acre.

The identity and importance of natural phenomena that kill ponderosa pine trees usually within 1 year were studied in western Montana between 1948 and 1965. So-called quick-acting causes considered in the study were: (1) fire; (2) windstorms; (3) lightning; (4) flooding; (5) land displacement from underground seepage or earthquake shocks; (6) damage from animals; (7) sudden concentrations of airborne pollutants; (8) defoliating insects, such as the pine butterfly, Neophasia menapia Felder and Felder (Lepidoptera: Pieridae); (9) bark beetles of the genus Dendroctonus (Coleoptera: Scolytidae); (10) certain other phloem-feeding beetles, principally Ips pini (Say) (Coleoptera: Scolytidae) and Melanophila californica Van Dyke (Coleoptera: Buprestidae); and (11) other but unknown causes.

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Tree killing by some of these causal factors is independent of predisposing influences that may weaken or damage the trees. Other causes of killing are effective only after the vigor of the trees has been reduced by environmental deficiencies, pathogens, or physical injuries. Hence, they may be termed "primary" or "secondary" causes of tree death depending on the degree of tree vigor they must overcome.

PROCEDURE

Pine tree mortality was recorded annually from 1948 to 1965 from an original selection of 10,600 mature, living ponderosa pine trees 12 inches diameter breast height and over. The trees were distributed throughout 34 plots established in representative old-growth ponderosa pine stands in Montana west of the Continental Divide between 1948 and 1959. The pine timber on 21 plots remained in a virgin state throughout the study. On 13 plots, it was subjected to selection cuttings that were considered light enough not to influence the nature and rate of mortality of the residual trees.

Dead trees were felled and limbed shortly after their discovery. These were carefully examined externally and internally to determine probable cause of death. The internal examination consisted of a stem analysis for which sections of the bole cambium were systematically exposed from the base to the top of the tree.

RESULTS

A total of 406 ponderosa pine trees died on the study plots between 1948 and 1965 from the effects of windstorms, bark beetle attacks, other but unknown causes, attacks of other phloem-feeding insects, and lightning strikes (table 1).

Trees were killed in the following ways:

Windstorms.--Trees were uprooted or their trunks were broken off below the bottom of the crowns by winds.

Bark beetles.--Lethal attacks on the boles of the trees, principally by the western pine beetle, Dendroctonus brevicomis LeConte, but also occasionally by the mountain pine beetle, D. ponderosae Hopkins.

Lightning strikes.--Trees not shattered or fired by lightning strikes, as sometimes happens, but marked with a narrow strip of exposed cambium parallel to the grain of the sapwood indicating the course of the electrical charge between the top and base of the trees. Most of the lightning-struck trees observed during the study were heavily attacked by the first subsequent flight of emerged Dendroctonus beetles.

Other phloem-feeding insects.--Lethal attacks on the boles of the trees, chiefly by the pine engraver, Ips pini, and the California flatheaded borer, Melanophila californica.

A distinction was made in the study between bark beetles of the genus Dendroctonus and the other phloem-feeding insects because the two groups represent different problems in the protection of ponderosa pine forests. Bark beetles traditionally kill more trees in stands of mature ponderosa pine over a period of time than do the pine engravers or flatheaded borers.

Table 1.--Mature ponderosa pine trees 12 inches d.b.h. and over killed on 34 plots in western Montana between 1948 and 1965

Causal agent	Trees killed		Volume killed [1]	
	Number	Percent	Gross bd. ft.	Percent
Windstorms	231	56.9	208,360	57.0
Bark beetles	121	29.8	97,830	26.7
Lightning	16	4.0	28,120	7.7
Unknown causes	18	4.4	21,290	5.8
Other insects	20	4.9	10,250	2.8
Total	406	100.0	365,850	100.0

[1] Scribner Decimal C volume table.

The pine engravers ordinarily attack and kill only the smallest of the mature pine trees. These are populations that usually have developed from pine slash or snow breakage that has accumulated in the forest. Attacks by Ips are more indiscriminate and usually less predictable, whereas those by bark beetles generally are more selective. Trees susceptible to D. brevicomis, for instance, can usually be identified with considerable accuracy in many parts of the Western United States by applying the Ponderosa Pine Risk Rating System.[2] This system's effectiveness is currently under investigation in western Montana.

Trees killed by lightning strikes alone were not observed during the study. A few trees were found that had been struck, but these showed no visible sign of damage other than the telltale narrow strip of exposed cambium marking the course of the electrical charge.

The 16 trees classified in table 1 as lightning-killed constituted about 80 percent of all those known to have been struck on the plots during the study. Each of the 16 trees was heavily attacked by the first subsequent flight of newly emerged Dendroctonus beetles, primarily those of D. brevicomis. Although these trees presumably died from the direct effects of these attacks, it is doubtful if most of them would have been attacked by Dendroctonus beetles had they not first been struck by lightning.

Only four of the 16 trees were rated as risk 3 or risk 4 according to the risk rating system and hence highly susceptible to attack by the beetles. Because of the great attraction of lightning-struck trees to D. brevicomis,[3] the 16 trees considered here were judged in the study to have died as a result of the predisposing, or primary, effects of the lightning strikes and not from the followup, secondary attacks of the bark beetles.

[2] Salman, K. A., and J. W. Bongberg. Logging high risk trees to control insects in pine stands of northeastern California. J. Forest. 40(7): 533-539. 1942.

[3] Johnson, Philip C. Attractiveness of lightning-struck ponderosa pine trees to Dendroctonus brevicomis (Coleoptera: Scolytidae). Entomol. Soc. Amer. Ann. 59(3): 615. 1966.

The trees killed by the causal agents listed in table 1 were reasonably well distributed throughout the plots and the period covered by the study, except for trees killed by windstorms. Two-thirds of the trees killed by windstorms were concentrated on five of the 34 plots. During the period of the study, each of the five plots had been subjected to at least one localized windstorm of hurricane force that contributed to catastrophic blowdowns of pine timber within and adjacent to the plots. Two of the plots were buffeted by similar winds a second time. Wind-caused tree killing was more evenly distributed over the remaining 29 plots, although it was concentrated in a few locations in a way to suggest that topography might be related to this type of damage.

The year-after-year importance of the tree-killing factors listed in table 1 can be best appreciated from the following tabulation. This shows the annual rate of loss per acre in the ponderosa pine stands covered in this study that could be attributed to each of these factors.

Causal factor	Gross board feet
Windstorms	44
Bark beetles	21
Lightning	6
Unknown causes	5
Other insects	2
	78

The annual loss caused by bark beetles reflects the endemic nature of populations of D. brevicomis and D. ponderosae that were prevalent in western Montana during the life of the study. Mean annual losses of from 100 to 300 board feet per acre are not uncommon from epidemic populations of D. brevicomis in stands of mature ponderosa pine.[4]

[4] Miller, J. M., and F. P. Keen. Biology and control of the western pine beetle. U.S. Dep. Agr. Misc. Pub. 800, 381 pp. 1960.